HISTORY

OF

THE DEPARTMENT OF ELECTRICAL ENGINEERING

THE OHIO STATE UNIVERSITY

by

Emerson E. Kimberly B. E. E. 1921, M. Sc. 1929

INTRODUCTION

In writing this history the late Professor Kimberly drew upon many sources, not the least of which was his personal association with the Department for more than two-thirds of its existence. Inevitably his style and viewpoints are interwoven with the text and add a certain charm for those of us who knew him well. We have therefore minimized the editing of the manuscript he left.

From time to time we hope to revise this history and keep it current. In this effort the comments, advice, and assistance of alumni and former members of the staff would be most helpful and indeed are urgently sought.

M. O. Thurston

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In the Beginning

In the eighteenth century and early in the nineteenth, electricity was a toy for small boys with cat fur and glass rod, a challenge to a certain legendary reckless flyer of kites and a mystery for natural philosophers in colleges to wonder about. But with the coming of the motor and the arc lamp, the Helmholtz and Winshurst machines gathered dust while the natural philosophers, now known as physicists, gathered around the new-age wonders.

One of those physicists was Dr. Thomas C. Mendenhall, Professor of Physics, at Ohio State. He urged the teaching of applied electricity and obtained in 1884 two dynamo machines for the physics laboratory in University Hall. He was succeeded as Professor of Physics by Benjamin F. Thomas, who was also interested in motors, dynamos and electric batteries. Engineering is the art of reducing to practice the fundamental findings of physicists and other scientists. Professor Thomas was one of those excellent men of physics who liked the applied branch of his profession and so taught the first courses called electrical engineering

at Ohio State. But laboratory equipment was lacking. On October 4, 1887, Professor Thomas wrote a letter to President William H. Scott as follows:

> "...I wish also to ask your attention to another matter. You are aware that there is an increasing demand among our students, and from without, for work in applied electricity. This demand has been met so far as our equipment will enable us to do it. Electrical Engineering is rapidly becoming a profession and soon must take its place beside mechanism and civil and mining engineering in the work of technical schools. The rapid extension of electric lighting, electric railways, the use of electric motors in manufacturing, etc., calls for young men thoroughly trained both in the science and in the art of electricity. The University ought to supply the demand for Ohio, at least, but we cannot give young men a training which, when put to the test of practical use, will be satisfactory either to themselves or to their employers until special provision is made. Sound theoretical knowledge is necessary to the highest success and can be given with but little apparatus, but theory alone is not sufficient. It must be supplemented with thorough practical knowledge before a student can enter on a practical life for which he has been fitting himself. I ask that an appropriation be made for this purpose. We need equipment with which practical instruction can be given in the use of such electric machinery as is now used commercially. This will comprise a steam engine, at least four dynamo machines of commercial size, an electric motor, dynamometers, arc and incandescent lamps, and the necessary line wires, insulators, switches, etc. etc. The machinery will need a small building which will not be expensive. I respectfully urge that an earnest effort be made to secure the necessary means from the next legislature."

In the Annual Report to the Board of Trustees in 1887 (Honorable L. B. Wing, President) by President William H. Scott are found the following statements:

> Physics:
> "... The prominence now given to the subject by the rapid development of the application of electricity, the desire for

> instruction in the subject and the demand for instructed men make a strong plea for the supply of the means for thorough practical work at the University. I hope that we shall not be obliged to wait long for what is so needed."

In 1888 President William H. Scott reported to the Board of Trustees that:

> "The equipment of the department of physics has recently been reinforced with a steam engine of excellent workmanship and finish, and a six-light dynamo. The engine was loaned by the New York Safety Power Company and the dynamo by the Thompson-Houston Electric Company of Lynn, Massachusetts.
>
> The arrival of the new engine and dynamo have created a new necessity. We have no suitable space for them. They have been set up temporarily in the basement of the main building (University Hall) but we shall not leave them long in a location so unfit for continuous work. A separate building should be provided without unnecessary delay.
>
> These timely additions have enabled the professor of physics to offer a special course in electrical engineering, thus meeting a demand that has often been made upon us."

Thus was born Electrical Engineering at The Ohio State University. The first degrees (M. E. in E. E.) were awarded in 1891 to N. W. Storer and G. N. Cole.

It is interesting to note in the university catalogs from 1889 to 1895 that the program leading to the M. E. in E. E. degree was administered by the Department of Physics and Electrical Engineering. From 1895 on, Electrical Engineering was listed as a separate department although it was not separately budgeted until 1898.

In 1893 the courses entitled Electrical Engineering as offered under Professor Thomas were limited to the study of dynamos, motors,

transformers, arc lamps, the telephone, the telegraph, storage batteries, circuits and instruments. As an informal part of the laboratory equipment there was a generator driven by a 100 hp engine in the mechanical engineering laboratory. This generator furnished all electricity for Chemical Hall, Hayes Hall, Orton Hall, Electrical Hall, University Hall, and farm. Wiring of buildings and of circuits in the tunnels was planned and carried out by students in electrical engineering courses. The pay was at the prevailing rate of ten cents per hour. A short telephone line said to be the first in Central Ohio was constructed between University Hall and Eleventh Avenue at High Street and used as a laboratory line.

By 1896 a two-phase power system was being provided to take the place of the older single-phase and direct-current systems. About 1900 the campus power and lighting system was entirely separated from the electrical engineering department.

Laboratory Maintenance

Laboratory funds being small, it was soon found expedient to exact a fee from those students taking laboratory courses in order to cover the cost of equipment repair and consumable supplies. Accordingly the department was authorized in 1897 to "exact from each student in the dynamo laboratory a fee of $2.00 each term to pay for any loss or damage to the property in such laboratory which may be traceable to him". This fee in varying amounts was charged as a regular practice

until about 1954, when it was discontinued. After that year all maintenance costs were charged against a covering annual departmental appropriation.

Electrical Hall

By the year 1889 there was not enough space in the basement of University Hall for the proper use of the new engine, dynamo and other newly-acquired power equipment. So in that year the Ohio State Legislature appropriated $10,000 for a new building and equipment. In the same year the building was built at the northeast corner of Seventeenth and Neil Avenues. In 1892 it was named Electrical Hall.

Electrical Hall was a two-story brick building 75 feet by 45 feet. With its equipment it was valued at $18,000. On the first floor was the office, dynamo laboratory apparatus room, shop, dark room and calibration room. On the second floor was a lecture and drafting room, office, library, photometric laboratory, magnetics laboratory and telephone laboratory. On March 4, 1914, while being used by the Department of English, Electrical Hall was destroyed by fire.

Robinson Laboratory

By 1906 Electrical Hall proved to be too small for the growing young department and Robinson Laboratory was built. The cost was $75,333. The Laboratory was named in honor of Stillman W. Robinson,

Figure 1
Electrical Hall

Figure 2
Robinson Laboratory

an earlier chairman of the Mechanical Engineering Department. Its use was shared by the Electrical and Mechanical Engineering Departments with electrical occupying about ninety per cent of the north half.

At the time of this Centennial Celebration, Robinson Laboratory is still in use, although none of it for electrical engineering. It is the first college building in the United States with a saw-tooth roof design.

Robinson Laboratory, of about 35,000 square feet, was originally built with offices and classrooms in two stories in both the north and south ends. The space between was used largely for heavy-machinery laboratories extending from floor to skylight roof. In 1948 a second floor was added above the electrical machinery laboratory to provide communication equipment laboratories and offices and classrooms.

Communications Laboratory

In 1918 another brick building with saw-tooth roof design was built west of Robinson Laboratory and was first used as a wartime aeroplane hangar and mess hall. As part of their training in this building, the flyers were instructed Morse Code by Associate Professor Emeritus Robert C. Higgy, then a high school student and radio amateur. In 1922 the University's radio station, WEAO, was installed in its northeast corner under the supervision of Professor Roy Atkinson Brown of the Department of Electrical Engineering.

In 1923 the department started to expand into the building and

ultimately used all remaining space for classrooms, offices, laboratories and a machine shop. The first electron microscope built in the United States was constructed by Dr. Albert F. Prebus in a portion of this building in 1940-42. Since the building of Caldwell Laboratory at Nineteenth and Neil Avenues, electrical engineering activities have been slowly phased out of Communications Laboratory until, at this Centennial time only about 10% of the building is so used.

Caldwell Laboratory

In 1950 the first part of Caldwell Laboratory was built with four stories and basement and with a three-story wing extending south from the east end. It was first occupied in 1951. Its walls are of brick and aluminum and sheet steel. Its floors are of cellular steel construction with raceways for flexibility in rearranging the electrical wiring when needed because of changes in use of space. In 1960 a three-story wing was built at the west end parallel to Neil Avenue, and a basement was constructed between the two wings to be used as a power machinery laboratory. In 1965 the rectangular enclosed space was filled with classrooms and laboratory rooms, thus actually constituting a separate building immersed in but joined to the previously constructed building. This last addition to Caldwell Laboratory was funded in part by a grant of $375,000 from the National Science Foundation.

Figure 3
Caldwell Laboratory

ElectroScience Laboratory Building (See Also p. 82)

In 1956 a new Antenna Laboratory Field Station with a floor area of 12,712 square feet (gross) was opened on Kinnear Road for antenna research, radar reflection studies, and radome research. In 1961-62, with a grant of $435,000 from the United States Air Force, four 30-foot parabolic reflectors were installed as an antenna array to be used in research dealing with intercontinental and interplanetary communication. The control and instrumentation equipment associated with these antennas is housed in a specially designed building directly below them. After the addition of another 10,500 square foot section onto the Antenna Laboratory building, the expanded complex was renamed the ElectroScience Laboratory. In addition to these buildings, the laboratory also occupies part of an adjacent Research Center operated by The Ohio State University Research Foundation. The activities of this Laboratory will be given in more detail as an appendix--The History of the ElectroScience Laboratory.

Radio Observatory Buildings

The Radio Observatory, now located on Route 23 south of Delaware, Ohio, had its beginning in 1956 when a dish antenna was completed on the west campus. Also in this year, through a grant from the National Science Foundation, work was started on a 360 foot by 70 foot parabolic reflector at the Delaware site. The main building has about 1800 square feet. This research will be described in a later part of this history.

Figure 4
ElectroScience Laboratory

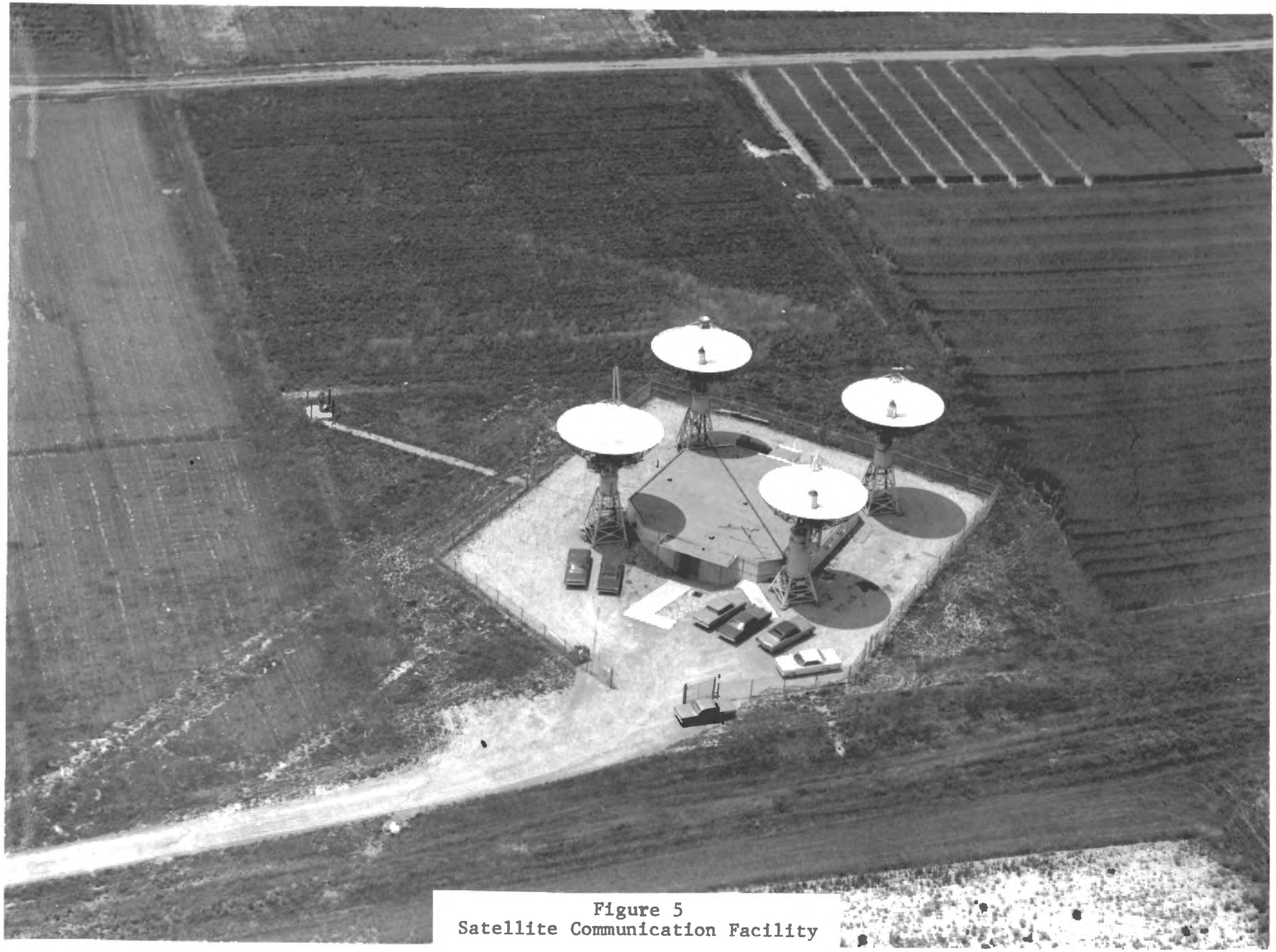


Figure 5
Satellite Communication Facility

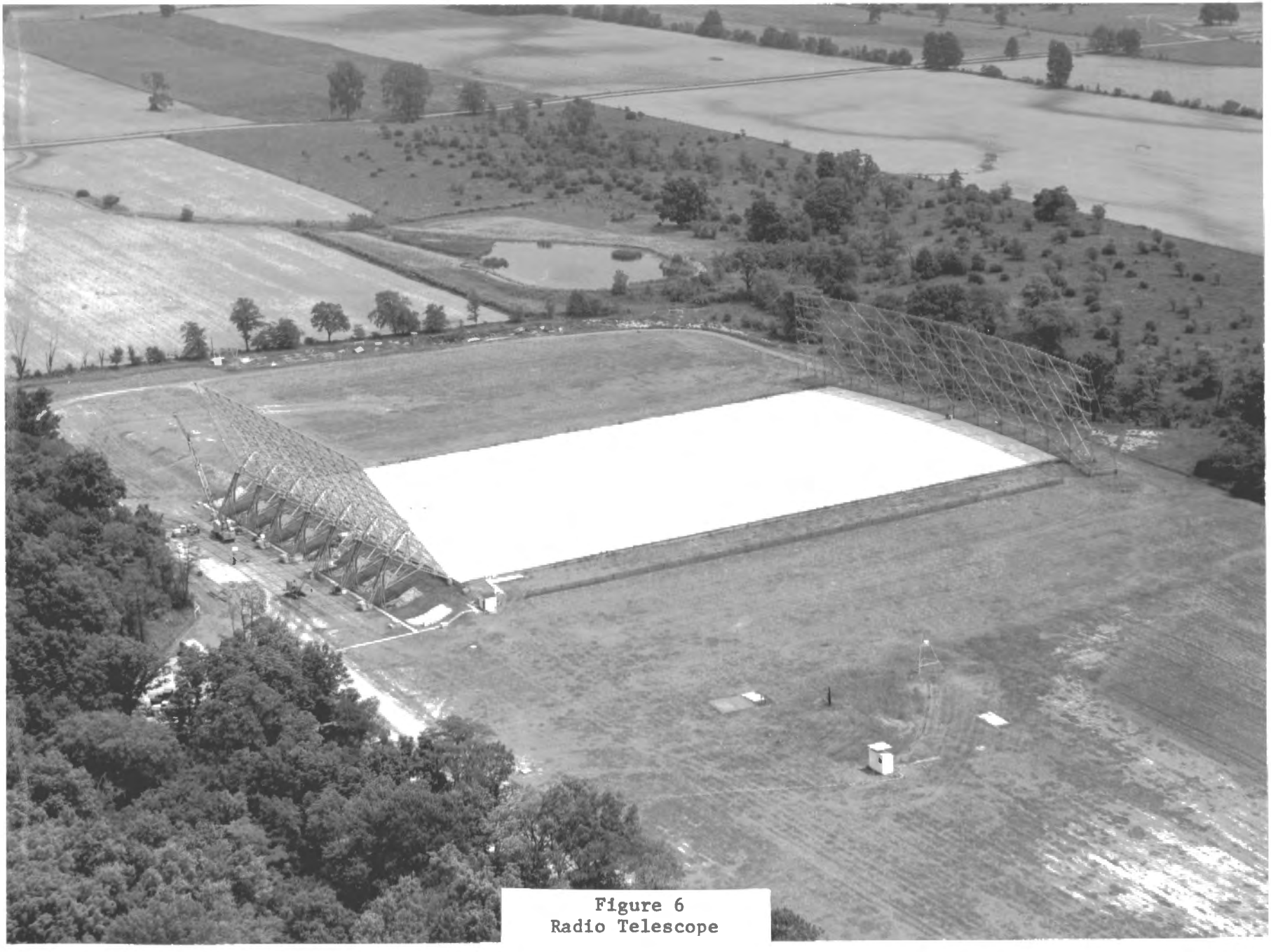


Figure 6
Radio Telescope

Electronics Laboratory

One of several buildings included in the long-range plans of the College of Engineering was the Electronics Laboratory. Through the efforts of the Committee of One Hundred for Engineering and others, the necessary bond issue was passed and funds became available for its construction. Detailed departmental planning began in 1964, and the new building was occupied in March 1969. A formal opening ceremony was held on May 23rd, 1969, with Dr. George E. Mueller as principal speaker.

The building consists of eight floors and a basement with special facilities for electromagnetic and solid state electronic research. Substantial additional space is designed to be sufficiently flexible to accommodate a wide range of research, student laboratories, or classroom instruction. This new building is connected at the second floor level to Caldwell Laboratory by means of an enclosed bridge over Neil Avenue.

Figure 7
Electronics Laboratory

THE CURRICULA

Dr. Mendenhall and Professor Thomas regarded the new electrical engineering as reduction to practice of findings in the realm of physics for the benefit of man in lightening his work, extending his capabilities and making a profit for him. Part of the pressure which those men felt came from businessmen who sensed industrial potential. It came also from young men who wanted to be a part of the exciting new adventure.

The curriculum first offering electrical engineering courses did so most modestly and only in the senior year. See Appendix I. It was envisioned that those graduating would become some kind of super-technicians, some of whom would design the electrical apparatus and others of whom would supervise its installation and operation as employees of other men who ran businesses for profit. Here was a chance for a young man to become an actor in a new phase of the Industrial Revolution. In fact, Charles F. Kettering, M. E. in E. E. 1904, said many years after his graduation, "When I got my diploma the first thing I wanted to do was find somebody who was trying to make a profit and wanted to hire me to help him do it."

There was another viewpoint, however, in which it was held by some that college is a place where one comes to be educated, that is, to learn to think and to know the humanities involved in understanding and living with other persons.

In a letter of October 4, 1921, Dean Embury A. Hitchcock wrote to the Engineering College Faculty as follows:

> "... Referring further to our small efforts during this past year in the field of human engineering, I trust that we may give this field of engineering such consideration and so recognize its importance that a place will be made for this study in our new program. The engineers of the future will be the balancing power between Capital and Labor; therefore, the great human problems that they will be called upon to solve will be just as important, yes, more important than the building of the most modern structure, the construction of a great system of railways, or the planning of most extensive power systems..."

But in the rush into technology the humanities continued to fare badly in the early electrical engineering curricula. Growth favored the technical in 1893-94 as shown in Appendix II. Electrical Engineering was offered only in the senior year. Courses in the humanities were approached cautiously at first by offering them as non-technical electives with wide limits of choice. In the early 1940's in a more expanded curriculum, the choice was controlled more closely.

But the content of course offerings persisted in following the trends in industrial evolution. By 1907 lighting by electricity had brought a demand for engineers trained in the art and science of illumination. A new three-hour optional course entitled "Electrical Illumination" was offered for the first time. Interest in that subject was kept alive for thirty-five years by Professor Francis Cary Caldwell, who was the first chairman of the new department. The course offerings fell victim of World War II when electronics was making a spectacular rise and interest

in illumination and demand for specialists in it competed poorly for space and time.

Electric railways had their day too. In 1906 an optional course in electric railways was offered for the first time and was taught by John E. Shepardson. It flourished until the 1930's when its title was modified to transportation for more general content and then was finally phased out in the late 1930's. Professor Shepardson left the University in 1932. A pattern has now begun to show in which is correlated a time of flourishing of a particular subject and the period of activity of some particular faculty member.

In 1909 the first course in what would now be called Radio was offered. It was named Wireless Telegraphy and was taught by Assistant Professor Walter L. Upson. It cannot be said, of course, that Wireless Telegraphy ever "phased out" because its essential content was merged with Telephony introduced in 1906. Both subjects were soon to lose their identities in their further merging into more generalized studies. Two-hour optional courses in railways, illumination, telephony and wireless were all being offered in 1913.

In 1917 the first course in Radio Communication was offered. In 1958 the courses in motors, generators, and transformers were modified and combined under the general class of Energy Conversion. In 1953 the first course in Transistor Theory was offered.

In this centennial year this department offers 71 undergraduate optional and required courses and 49 graduate courses (see Appendix III).

Quarter Plan or Semester Plan?

In the beginning, the University divided the academic year into quarters. The quarters in which regular sequential courses were offered were called Autumn, Winter, and Spring according to their time of year. Some special, though required, course work was offered in the Summer quarter as well.

But a few inventive and dissident minds on campus thought the quarter plan was a stupid and ineffective framework around which to mold superior intellects. It was, therefore, proposed that the active academic year be divided into two semesters running through about the same months as the Autumn, Winter, and Spring quarters had previously. The first two-term plan was recommended for adoption in 1908 but was successfully opposed for many years. The final proposal was adopted and put into effect as the Semester Plan beginning in 1917.

By 1921 opposition to the Semester Plan had grown so strong that the Quarter Plan was re-established in 1922. So since that time the teaching staff have again had an opportunity to correct their mistakes three times a year instead of two. If it is conceded that students as a whole are a hard lot to improve, then these term manipulations suggest that they are also a hard lot to ruin.

By 1968 the semester proponents had again become somewhat clamorous, but in this centennial year the matter has not again been brought to issue.

Four-Year Plan or Five-Year Plan?

To most of us, of course, the four-year college curriculum, though arbitrary, is traditional. However, when electrical engineering appeared in the Ohio State curricula, it did not do so by insinuating itself among the humanities or "broadening" subjects where it might grow unobtrusively and crowd them out. It arrived full-blown and left but little room for French, English, and Rhetoricals as may be seen in Appendix I. So the conflicts in viewpoints mentioned in this chapter came early. A five-year curriculum was considered lightly as early as 1910. It was not until 1922 that these conflicts erupted in debate, and a five-year curriculum was actually planned and seriously considered. After much delay and extensive planning the expanded curriculum was put into operation in the entire College of Engineering in 1945.

It was intended that the new five-year curriculum would contain not materially more technical subject matter. It was hoped that with the added year no more than forty percent would be engineering; the rest broadening or cultural, according to viewpoint. The non-technical subjects were scattered throughout the five years. See Appendix IV. The first two years were named Pre-Engineering years and the last three, the Professional Division years.

It was recognized, of course, that in most other universities a capable student could receive a master's degree in five years and might therefore be reluctant to enter the five-year bachelor's program. To

correct this difficulty, provision was made for students with a B or better average to register in the Graduate School during the fifth year and substitute graduate courses for undergraduate electives. Under this combined degree program the student would obtain both a bachelor's and a master's degree at the end of five years. In fact, the thesis requirement usually extended the time for the MSc by at least a quarter. The fraction of qualified students who elected to enter the combined program was low initially but gradually increased. But by that time (1950 or later) there were so many meaningful paying jobs available through sponsored research in the department that the student could win his advanced degree and live well too.

The reactions of engineering college administrators in other universities were mixed as was to be expected. All envied Ohio State the extra year. Of all non-cooperative type colleges only Cornell and Minnesota tried the five-year experiment along with Ohio State. Some in neighboring states said, "Let Ohio State have her five-year curriculum. We will get the students." Some industrial companies said, "Good," and offered premium starting salaries. Some companies said, "So what? Just give the boys four years of fundamentals and let us have them. We will see to it that they will have specialized training with us." But they too paid a little extra starting salary.

If one takes the purely money viewpoint he finds by capitalizing the cost to the student of the fifth year that it does not pay off. It would,

of course, if his salary kept a pace above that of his four-year contemporary brethern. But in a very short time after graduation day so many masking influences have operated that salary differential is no longer identifiable with the extra year in college. Let us hope the broadening course content has helped to make wiser and better-satisfied citizens for whom the benefits go on and on.

Ohio State's college of engineering has stood doggedly firm on its commitment to the five-year curriculum, but standing alone is difficult. Minnesota and Cornell for reasons of their own abandoned the five-year curriculum requirement for bachelor's degree in engineering. Ohio State capitulated in 1969. We still offer a master's degree after five years as before but also a bachelor's degree after four years. And so one more noble experiment passes into history.

Short Courses and Special Curricula

Wherever there exists a four-year curriculum there are persons who believe there should also be a short course for those students who may be short on prerequisites or funds. Early in the life of our Engineering College, two-year courses in Clayworking, Industrial Arts, Mining and Highway Engineering were offered. The same type of short course was considered for Electrical Engineering but was never adopted. All short courses in the college were discontinued after June 30, 1919. In 1944 an institute-type of curriculum was debated for college adoption to

start in 1945 but the plan was soundly rejected. In the period of World War II, this department was one of many in the Engineering College to offer special courses in the Engineering Science Management Defense Training Program of the United States Government. This program was locally under the direction of Professor Harry E. Nold of the Mining Engineering Department.

Since World War II the Ohio Society of Professional Engineers has arranged yearly for refresher courses to be offered to engineers planning to take the State examinations for professional registration under Ohio law. While Ohio State has taken no official part in these programs, it has provided classroom space and the teachers have been members of the University teaching staff who did the teaching as extracurricular activity.

In the early years of the department, a five-year curriculum with four-year content was adopted for use by students who needed to work too many hours to allow the carrying of a full load of subjects. This curriculum was soon abandoned in favor of individual scheduling by a faculty counselor and is not to be confused with the five-year curriculum put into effect in 1945.

THE HONORS GROUP

After some months of debate it was decided in 1927 to establish a separation of electrical engineering students to allow those qualified to move ahead of the class, to explore attractive byways, follow an active imagination and expand their visits to the full extent of their capabilities. They were to be known as Honors Group students.

Accordingly, those chosen as qualified were permitted, if they so chose, to attend class or not, ignore all examinations except the final examination of the quarter and study advanced subjects with the help of their instructors. They were to be self-directive.

But one problem was never solved: how to choose the qualified. It had been presumed they could be chosen on the basis of grades. It soon became evident that high grades are not proof that a student can be self-directive or that he will maintain his diligence when the only examination is weeks in the future.

Another problem was that those students remaining in the regular classes set up their own new standards of excellence lower than before because their high-standard bearers were gone. They also lost the stimulation of seeing good men in action.

Since the good of the plan was so hard to disprove, the Honors Group division was maintained despite its obvious shortcomings until World War II when shortage of both students and instructors forced its suspension. Since World War II the experiment has been quietly ignored.

THE HONOR SYSTEM

The Honor System is not to be confused with the Honors Group. The System applies to honesty in examination. The essential features of the requirements under which the students through their Student Council administer this honor system are as follows:

1. Instructors are required to announce the date, scope and type of examination at least three days before the examination.
2. At the beginning of the examination, the instructor will submit the questions to the students and instruct them to read through the entire examination. He will then ask if there are any questions concerning the problems and will answer all queries concerning the questions stated. Having completed this action he may leave or remain in the room at his own discretion. However, if he does leave the room he must remain within a reasonable distance from the classroom at a predesignated location.
3. Students may leave the room but not discuss the examination or refer to any illegitimate source of information.
4. At the end of the examination the student signs the following pledge copied on the same sheet as the last problem and immediately following it:

Pledge: No aid given, received, nor observed.

If a student is reported cheating in an examination, he is to be called before the Council and given a chance to plead his case. If, after having heard all the evidence, the Council finds the accused guilty, it makes recommendations to the Department Staff as to the disposal of his case.

Others have tried the Honor System. Some failed. Some have succeeded too. When the Electrical Engineering Department faculty decided in 1943 to try the honor system, they went next to the students. If it were to work, it must be promoted by the students and run by the rules laid down by them. They must also "police" it if necessary. They did all that.

Up to this Centennial Year only two students have been tried by Student Council. Not more than six warnings have been given. The honor system has contributed very significantly to morale.

BIO-MEDICAL ENGINEERING

The earliest recorded cooperative effort of the Electrical Engineering Department with a life-science group produced a high-frequency diathermy machine. Another produced a photographic scanner used to make radiographs of radioactive thyroid glands. Another accomplishment was the investing of small animals with radio transmitters to chart their normal life movements. This desultory approach to bio-engineering did little to foster a solid program of cooperation between the disparate disciplines but did demonstrate the need for cooperative efforts.

In 1965, however, the Electrical Engineering Department introduced an interdisciplinary program in Bio-Medical Engineering at both undergraduate and graduate levels. This program combines electrical engineering with such life-science areas as Physiology, Medicine, Bio-Physics, Pharmacology, Veterinary Medicine, Agriculture, Optometry, Speech, Hearing, and Psychiatry.

It is intended that a Bio-Medical Engineer be a competent engineer first in his own major area of electrical engineering with sufficient training to enable him to do his engineering in the life sciences. It is not usually the intent that an engineer be a specialist in his own field and an authority in a related discipline as well, but that he be sufficiently educated in the life-sciences to participate in the research and development in that area.

Technical elective content in the last year of the B. S. E. E. degree program may include up to seven hours from outside the department and possibly more by petition. Research in the bio-electrical laboratory is available in the Electrical Engineering Department or in one of the associated disciplines. See Appendix V. This appendix shows a block of course material in engineering and the physical sciences which have been organized specifically for the Bio-Medical Engineering student or is desirable course material. In addition to providing for a pre-medical program in engineering, course material has been planned to provide either three or six months of concentrated work in engineering for the medical student.

By the Autumn quarter of 1968 this Bio-Medical program had grown to include the entire College of Engineering in the form of a Bio-Medical Engineering Coordinating Committee with chairmanship in the Department of Electrical Engineering. The program is jointly sponsored through an Advisory Committee composed of the Deans of the College of Engineering (Chm.), Medicine, Veterinary Medicine, Agriculture, Biological Sciences, and the Graduate School.

Professor Herman R. Weed is the man most prominent in effecting the coordination of the sciences and engineering and cooperation between departments that has made this Bio-Medical Engineering program a reality.

DEGREES

Bachelor's Degree

In 1894 there were eight graduates who had specialized in electrical engineering in the Physics Department. However, probably because of the mechanical nature of the senior year, the degrees were awarded as Mechanical Engineer in Electrical Engineering (M. E. in E. E.). This designation was retained after Electrical Engineering became a separate department in 1895. The decision was made in 1911 to change the degree to B. E. E. to differentiate it from the Professional degree which was to be offered for the first time in 1913. The first degrees B. E. E. were granted in 1915. The change also indicated that the electrical content of the curriculum was enough to dominate the degree. The degree B. E. E. remains. Graph 1 shows the number of graduates with M. E. in E. E. and B. E. E. degrees by years from 1891. The two recipients in 1891 were Norman W. Storer and George N. Cole.

Master's Degree

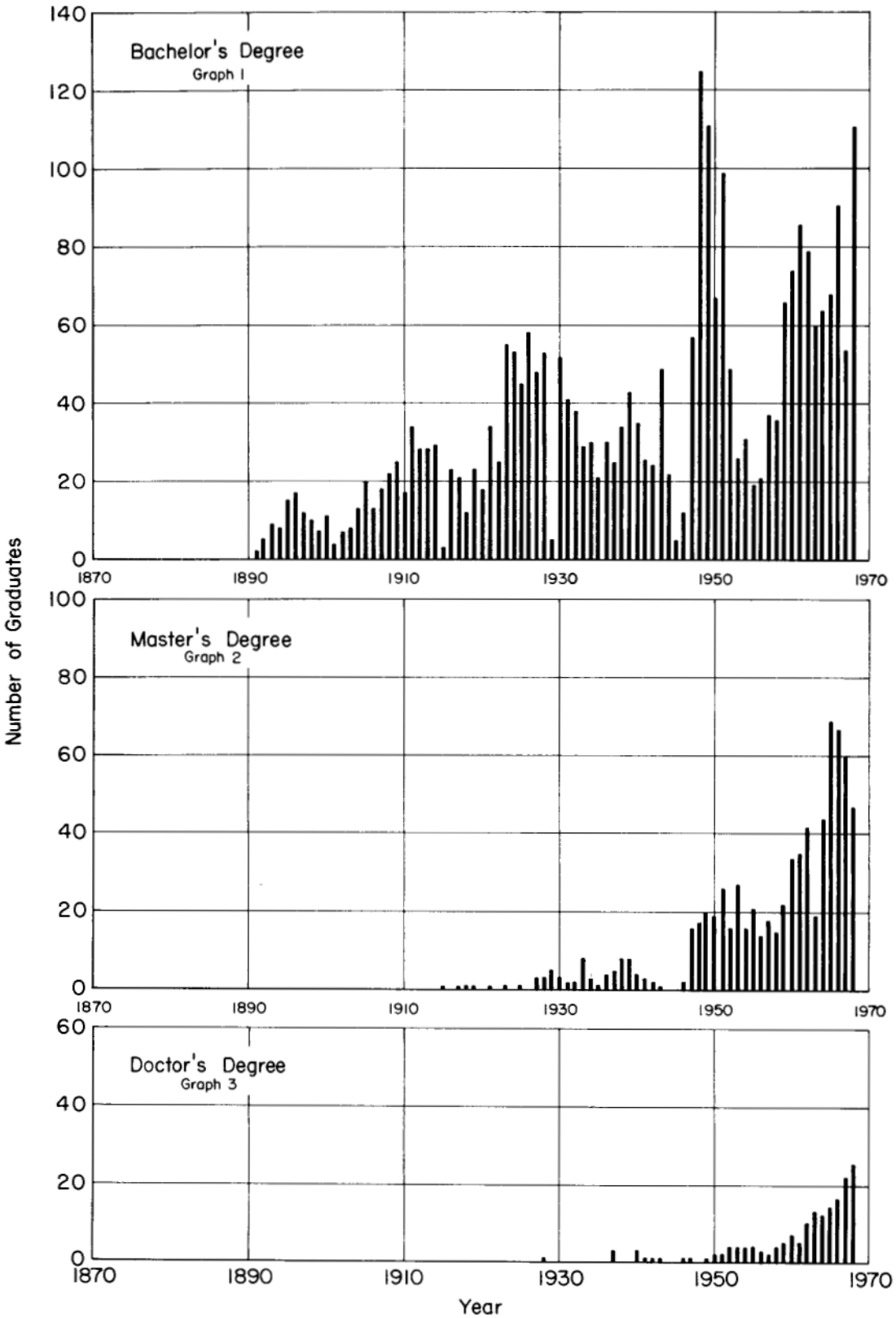
Although the Master's degree was first authorized in 1900, the first M. Sc. degree in electrical engineering was awarded in 1915. At that time most graduates entered the fields of design, manufacture or operation and the need for a Master's degree was seldom felt. Graph 2 shows the slow growth in numbers of Master's degree graduates until 1947

when the emphasis shifted, not because the old-type jobs were less available, but because the new jobs in research and teaching were so much more rewarding; and they required advanced degrees.

Doctor's Degree

The first Doctor's degree in electrical engineering at Ohio State was awarded to Kwan Yao Tang in 1928. Mr. Tang had received his Master's degree from the University of Michigan in 1925 and had confidently been promised an opportunity to earn his Doctor's degree at Ohio State if he would come here to teach. As the time approached to award his degree it was discovered that the Electrical Engineering Department had never qualified for teaching at the doctorate level. However, the hasty qualification avoided some imminent embarrassment and the degree was granted.

Graph 3 shows the rapid rise in numbers of Doctor's degrees after 1950. A big factor in the increase in numbers of both Doctor's and Master's degrees has been the great amount of sponsored research available through the Ohio State University Research Foundation through which men (and two women) found it possible to be self-supporting through such an extensive and expensive period of advanced study.


Bachelor's Degree
Graph 1
Master's Degree
Graph 2
Doctor's Degree
Graph 3
Number of Graduates
Year
0
20
40
60
80
100
120
140
1870
1890
1910
1930
1950
1970

Professional Degree

In 1923 the Professional Degree Committee of the Engineering College recommended to the faculty a Professional Degree be established and offered to graduates of the college who fulfilled certain professional requirements in their post-graduate practice. The recommendation was adopted by the Engineering College Faculty and the requirements for obtaining such were adopted as follows:

> "Upon nomination by the faculty of the College of Engineering the appropriate Professional Engineering degree of Electrical Engineer, Mechanical Engineer, etc., may be granted to graduates of this University upon any one of the following plans:
>
> First. Four years of acceptable professional experience and an approved thesis.
>
> Second. A Master of Science degree from this University with a major in Engineering followed by two years of acceptable professional experience and an approved thesis.
>
> Third. One year of acceptable professional experience followed by one year of approved study at this University with an appropriate engineering major and an approved thesis."

After several years of experience in giving this degree a general dissatisfaction with it arose because of alleged misuses and abuses. Furthermore, Professional Registration of Engineers had been established in Ohio in the early 1930's and it was believed that this state activity provided at least as much professional status as did our Professional Degree. Disapproval of the Professional Degree is believed to have been led by the Electrical Engineering Department. On March 4, 1941, the College of Engineering approved the dropping of the Professional Degree.

The University Commencement records show Professional Engineering Degrees have been awarded from 1913 until 1918. There seems, therefore, to be some confusion in the records. These earlier degrees were probably awarded with criteria different from those described here as beginning in 1923.

OFF-CAMPUS GRADUATE TEACHING USING AUDIO-VIDEO LINK

In 1962 the faculty of the Electrical Engineering Department who had been commuting every week to Wright-Patterson Air Force Institute of Technology at Dayton, Ohio, to teach graduate courses conceived the idea of teaching those classes through the medium of television and so saving the travel time.

Encouraged by Professor E. E. Dreese, Dr. E. Q. Moulton, then Associate Dean of the Graduate School, obtained permission of University officials to invest $10,000 in equipment for an experimental television link between Columbus and Wright-Patterson Air Force Base. The link consisted of wire communication to downtown Columbus and microwave to Dayton through two repeaters. The system provides two-way audio communication and one-way video communication Columbus to Dayton. It was put in service in 1963. Although there are some compromises that make the television link less desirable than person-to-person contact, it has so far been sufficiently successful to justify its continuing use.

BROADCAST ENGINEERING CONFERENCE

In 1937 Professor William L. Everitt organized an annual conference of representatives from radio broadcasting stations and equipment manufacturers and called it the Broadcast Engineering Conference. Its purpose was to bring together the makers and users of radio broadcasting equipment to discuss their mutual problems. It was held every February until Professor Everitt took war leave in the spring of 1944. Professor Everitt did not return. After a lapse of one year the conference was held for the last time in 1946.

SCHOLARSHIPS AND FELLOWSHIPS

What is believed to have been the first scholarship available for undergraduate electrical engineering students at Ohio State University was created by the University in 1896 in the amount of $300. At the same time the Legislature authorized $200 per year for janitor services in Electrical Hall.

At the time of this writing there are but three scholarship funds controlled within this department by a scholarship committee.

Lamme Scholarship

When Benjamin Garver Lamme, M. E. '88, died in 1925 he left a will which, when probated, provided two undergraduate scholarships every year, one for a mechanical engineer and one for an electrical engineer. They are known as Lamme Scholarships. They first became available in 1929 and one has been awarded every year since in the amount of $450 to an electrical engineering undergraduate. With recent changes in its administration the fund is expected to yield slightly less than $450 per year for a short time and then more thereafter.

Frank C. Caldwell Memorial Scholarship

Professor Francis Cary Caldwell, first chairman of the Electrical Engineering Department, died in 1953. In his honor his widow, Louise Orton Caldwell, a number of his former students, and other friends

designated all or part of their OSU Development Fund contributions to a scholarship fund to be known as the Frank C. Caldwell Scholarship Fund. Every year one or more scholarships of $500 or less are awarded to undergraduate electrical engineering students.

Gee Scholarship Fund

Eugene Carl Gee, M. E. in E. E. '97, died September 18, 1940, and his wife, Mona Fay December 16, 1963. By the terms of Mrs. Gee's will a scholarship fund in honor of her father, mother, and husband was established through the Research Foundation at Ohio State. One-third of the income from the investment of the fund goes to the Medical School and two-thirds to the Electrical Engineering Department for undergraduate scholarships. In 1968 the spendable funds distributed to this department was about $7,000. The number of scholarship awards and the amount of money for each is designated by a Scholarship Committee. The fund was established December 1, 1964.

DISTINGUISHED ALUMNI

Beginning in 1955 the Engineering College has cited one or more of its alumni for distinction because of accomplishments after their graduation. The alumni listed here are those chosen from graduates of the Department of Electrical Engineering.

1955 Davis, Alton Frank, M. E. in E. E. 1914

Alton F. Davis led a distinguished career with his concern for his fellow man. He was one of the principal promoters of the employees incentive system for which the Lincoln Electric Company has become renowned. He was the president of the Ohio State Alumni Association. While it was never recorded, it is well known by his friends that he was a "soft touch" for the down-and-out and helped many friends and would-be friends. He died May 25, 1959.

1958 Singer, Siegfried Fred

Fred Singer, B. E. E. 1941, has distinguished himself in the field of high-altitude research. He predicted the existence of two belts of radiation trapped around the Earth. These belts were later discovered by satellites and space probes. His work in discovering the origin of meteorites and his designing of artificial earth satellites and his

desire to pass his knowledge on to others through speeches and classroom work are the reasons Dr. S. Fred Singer is truly a distinguished alumnus.

1959 Newhouse, Russell Cornwell

In recognition of his ingenious contributions to the problems of air traffic safety and to the defense systems of his country, his leadership in guiding pioneering research and development efforts, and his devoted services to his community and profession, the faculty of the College of Engineering proudly has designated Russell C. Newhouse, B. E. E. 1929, M. Sc. 1930, as a distinguished alumnus.

1961 Chope, Henry R.

For his creative and inventive genious, his executive and administrative accomplishments, his contributions to the engineering profession through research, and his support of engineering education through his service to the Ohio State University, the faculty of the College of Engineering was proud to designate Henry R. Chope, B. E. E. 1948, as a distinguished alumnus.

1961 Chope, Wilbert E.

In recognition of his administrative and executive abilities, his outstanding accomplishments in the electronics industry,

his contribution to the engineering profession through research, and his support of engineering education through his service to the Ohio State University, the faculty of the College of Engineering was proud to designate Wilbert E. Chope, B. E. E. 1948, a distinguished alumnus.

1962 Behrens, Chester Carl

For his outstanding engineering and administrative achievements in the field of telephone communications, his civic and professional leadership and his participation in the guidance of engineering students and teachers, the faculty of the College of Engineering proudly designated Chester C. Behrens, B. E. E. 1926, as a distinguished alumnus.

1964 Hammerschmidt, Andrew Lewis

For his eminent achievements in radio and television, his contributions to America's missile and surface radar capability, and his demonstrated ability in translating his research and the work of others into useful engineering systems and stepping-stones for the future, the faculty of the College of Engineering was proud to designate Andrew L. Hammerschmidt, B. E. E. 1938, as a distinguished alumnus.

1965 Huffman, David Albert

In recognition of his outstanding career of early achievement as a teacher, scholar, scientist and engineer, and as a tribute to his proven ability to pioneer in opening new areas of knowledge rich in application potential, the College of Engineering was honored to designate David A. Huffman, B. E. E. 1944, as a distinguished alumnus.

1966 Sinclair, George

In recognition of his outstanding career as a pioneer in antenna modeling, his service as first director (in 1941) of the Ohio State University Antenna Laboratory, his academic leadership in establishing the first doctorate program in Electrical Engineering at the University of Toronto and also establishing a doctorate curriculum in radio astronomy at that university and being the principal organizer of the Canadian Electronics Conference held in Toronto in alternate years, the College of Engineering was proud to designate George Sinclair, Ph. D. 1935, as distinguished alumnus.

1968 Anderson, A. Eugene

In recognition of his outstanding career in organizing, directing and coordinating the joint Army-Navy electron tube program, his pioneer work with transistors, bistable

circuits, transistor trigger circuits, a band-width reduction system, cathode-ray devices and storage tube circuits and also of the single honor of being named Distinguished Engineer by the Lehigh Valley Chapter of the Pennsylvania Society of Professional Engineers, the College of Engineering was proud to designate A. Eugene Anderson, B. E. E. 1939, as distinguished alumnus.

1969 Rench, Carl F.

In recognition of his important innovations in the development of electronic accounting and data processing equipment, his leadership in the development and production of high-performance peripheral systems for digital computers, and his accomplishments as an engineering executive, the College of Engineering was proud to designate Carl F. Rench, B. E. E. 1943, as distinguished alumnus.

RESEARCH

It is generally believed in the Electrical Engineering Department that sponsored research can be justified in an educational institution only if it provides a better environment for learning--especially graduate study. With this purpose in mind there are many research projects sponsored through the Research Foundation and the Engineering Experiment Station supervised by faculty members either individually or through three departmental laboratories and the Radio Observatory.

1. ElectroScience Laboratory
2. Electronic Materials and Devices Laboratory
3. Communications and Control Systems Laboratory
4. Radio Observatory

ElectroScience Laboratory

In the early years of World War II there grew a pressing need to identify airplanes at a distance as to type and number. In 1935 Dr. George Sinclair received his Doctor's degree from Ohio State. In his doctoral studies Dr. Sinclair developed the theory of antenna modeling which enabled an investigator to scale an object such as an airplane on which an antenna was mounted so that the scaled antenna and vehicle would have the same electrical properties as the full-scale system.

This significant research led to contracts with the United States Air Force through the Ohio State University Research Foundation and to

the formation of the Antenna Laboratory as a research division of the Department of Electrical Engineering. Because of the diversity of research later undertaken, the laboratory has since been named the ElectroScience Laboratory. Dr. Sinclair was its director from 1941-47 when he resigned to accept a position on the faculty of the University of Toronto.

The ElectroScience Laboratory has at the time of this writing about thirty-three sponsored research projects which may be classified broadly in the following categories:

Re-Entry Plasma EM Noise Investigation

Medical Applications of Holography

Laser Applications

Radiation Scattering

Radar Studies

Antennas and Radomes

Asymptotic Solution to Diffraction by a Wedge

Generation of Acoustical Waves in Non-Linear Piezoelectric Crystals by Optical Fields

Tuned Resonant Surfaces and Measurement of Constitutive Parameters

Transmission Line Techniques

Investigating Optical Properties of the Sea Relative to Subsurface Target Detection

From 1947 to 1954 the Laboratory was under the direction of Professor

Victor H. Rumsey. From 1954 to 1962 its director was Dr. Thomas E. Tice and from 1962 to 1969 has been Dr. Curt A. Levis. The present director is Dr. Louis L. Bailin. A more detailed history is appended.

Electronic Materials and Devices Laboratory

With a United States Air Force grant of $230,000 in 1946, a laboratory was started in the Electrical Engineering Department to conduct research on special electron tubes for high-frequency use. It started operations in 1948 as the Electron Devices Laboratory and was located in Communications Laboratory. Its first director was Professor E. Milton Boone.

In 1958 the facilities were expanded to include work in semiconductor devices and material research and development. Until 1965, this work included electronic material research, growth of crystals, diffusion phenomena and evaluation of new devices and their properties. Since February 1965 there have been added some other fields of research under a new director, Dr. Arthur E. Middleton. These added fields are new aspects of crystal growth and material deposition, study of optical, thermal, thermoelectric and electronic properties of crystals and films. The laboratory is expanding rapidly and as of the present (1969) occupies 2,000 square feet in Communications Laboratory and also occupies space in Caldwell Laboratory.

A number of United States Air Force and Signal Corps research

projects were funded in the early years of this laboratory. Some examples are:

Theoretical and Experimental Studies on the Millimeter-Wave Cavity Barkhausen-Kurz Oscillator

Low-Voltage Operation of the Retarding-Field Oscillator at X-Band and in the Millimeter Wavelength Region

Small Signal Theory of the Mixed-Field Reflex Oscillator

Oxide Surface and Interface Impurity Distributions

Phosphorous Distribution in the Oxide and the Interface Region for a SiO_2-Si System

Electrical Properties of High-Purity Boron

Study of Parametric Amplification

Solid-State Materials for Transducers

New Semiconductor Devices

Since 1965 the research projects have been funded by the United States Air Force, the OSU Engineering Experiment Station, United States Army, and National Aeronautics and Space Administration. These projects are:

Solid-State Electronic Techniques

Luminescence of Rare-Earth-Activated II to VI Compounds

Se and Se-Te Crystals for Tunable Optical Oscillators

Ion Implantation in Semiconductors and Insulators

Solid-State Targets for X-Ray-Sensitive Image Pickup Devices

Growth of GaAs Crystals

V-L-S Growth of $\alpha + \beta$ Rhombohedral Boron Crystals

Solid-State Nuclear Radiation Detectors

CdS Thin-Film Triode Research

GaAs Device Research

High-Figure-of-Merit Thermoelectronic Research

For courses in solid-state devices, see Appendix III. E. E. 720, 724, 725, 727, 732, 830, 831, 832, 833, 837, 838 (724 and 725 too new for Appendix III).

Communication and Control Systems Laboratory

In 1959 the University appropriated some starting money to investigate the use of electronics on the highways. This project was started in the ElectroScience Laboratory but was housed in Caldwell Laboratory. In 1960 the project was funded for one year by the Ohio Department of Highways and the Bureau of Public Roads to study the use of electronic devices as traffic aids. This study was to include a stranded-motorist detector, a vehicle longitudinal control system and the driver-vehicle interface.

In November 1963, several research projects were separated from the ElectroScience Laboratory and established as a separate research group known as Communication and Control Systems Laboratory under the direction of Dr. Robert L. Cosgriff. By that time the aim of the highway research had been changed to the complete automation of highway systems. By this automation it is hoped it may become possible and feasible to drive

an automobile onto the on-ramp of a major highway, lock its control system to the guidance system of the highway and give the driving no more personal attention until the automobile has reached the off-ramp which was programmed into its memory when it entered the highway.

A new contract was awarded for the period 1962-65 and an extension of it for 1965-68. As this history is being written the project is sustained by another one-year extension. By the middle of 1969 the total appropriation expended will be approximately $800,000. Since 1967 this automation project has been carried on in Caldwell Laboratory under the direction of Dr. Robert E. Fenton.

Members of the laboratory have also conducted extensive research in the areas of pattern recognition, digital systems, modern control theory, and legged locomotion. The present director of the laboratory is Dr. Robert B. McGhee.

Radio Observatory

The heart of a radio observatory is a radio telescope which will detect and record electromagnetic radiation arriving from outer space.

Construction of such a telescope, the first at Ohio State, was started in 1951 by Dr. John D. Kraus, Professor of Electrical Engineering. It consisted of an array of helices mounted on a tiltable groundplane. When completed in 1953, this array had 96 helices on a groundplane 160 feet long and 22 feet broad. Each helix was 10 feet long and had 11

turns. It was located on the university farm off Kenny Road. In such an antenna, elevation is selected by adjusting the tilt of the groundplane and the scanning sweep of the sky is provided by the earth's rotation. With the assistance of Dr. H. C. Ko, a Mercator projection was made showing radio radiation from nearly the entire sky observable from Columbus, Ohio. It is one of the most complete and detailed maps of the radio sky (made at 250 MH_z) showing sources as well as background radiation.

Although radio telescopes are able to penetrate great distances into space, they are severely handicapped in ability to distinguish between objects which are close together. In order to make a detailed map of a galaxy a much larger telescope was needed.

In 1956, construction of a larger telescope was started near the Perkins Observatory off Route 23 south of Delaware, Ohio. The new telescope has a tiltable flat reflector 260 feet long by 100 feet high (slant height) which collects radio signals from outer space and reflects them into a fixed standing paraboloid 360 feet long and 70 feet high. The paraboloid brings the signals to a focal point near the collector where they are received by large electromagnetic horns. From the horns the energy travels through waveguides or cables to radio receivers in a near-by underground laboratory. A three-acre groundplane of aluminum lies between the reflector and collector.

With this newer telescope a detailed radio map of the Andromeda galaxy (M31) has been made at 1415 MH_z. An all-sky survey at 1415 MH_z

is being made at the time of this writing. It has been in progress for several years and will require probably two more years to complete.

The funds for this work have been provided by National Science Foundation, Mershon and OSU Development Funds, and the Caroline Lovejoy Fund of the Engineering College (initial grant).

Engineering Experiment Station Research

The Ohio State University's Engineering Experiment Station provides research funds every year to the Electrical Engineering Department and others. Some of these funds are directed to specific projects and some to the Radio Observatory and four named departmental laboratories without specific designation. The following listing is intended to show the types of projects funded by the Station:

p-n Junction Arrays in X-Ray Imaging

Reduction of Dimensionality of Large Systems

Laser Theory

Study of Radio Telescope Antennas

The Polarization of Ionospherical Reflected Waves as an Indicator of Stratospheric Irregularities

Radio Radiation from Astrophysical Plasma

Radio Observatory

Electronic Materials and Devices Laboratory

Communication and Control Systems Laboratory

ElectroScience Laboratory

THE CHAIRMEN

Caldwell, Francis (Frank) Cary

A. B. Cornell 1890, M. E. 1891

1891-1892 Thompson-Houston Electric Company, Lynn Massachusetts

1892-1893 Student at National Polytechnic Institute of Zurich, Switzerland

Professor Caldwell came to Ohio State in 1893 as Assistant Professor of Physics. In 1897 he became Associate Professor of Electrical Engineering. In 1903 as full Professor he became the first Chairman of the newly-formed Department of Electrical Engineering. He was charged with the responsibility "to decide upon and make contacts for a new power house and plant." He was expected also to superintend the electrical work of new buildings.

In 1894 he was appointed to the Committee of Awards in the Department of Electricity at the World's Columbian Exposition in St. Louis. There he was also appointed Chairman of a subcommittee on electric lighting. In 1913 he was appointed to the first advisory counsel for the Ohio State University Experiment Station. He was a Trustee of Antioch College from 1909-1934.

In the academic year 1924-25 Professor Caldwell was on leave to spend a year in Prague, Czechoslovakia lecturing on electrical illumination and electrical transmission at the Czech Institute of Technology Polytechnicum

at Prague and Brunn. He also lectured under the auspices of the German Institute of Technology, The Czech National Society of Electrical Engineers and the Austrian Society of Illuminating Engineers in Vienna.

In recounting his adventures while lecturing before foreign students, Professor Caldwell said he had been assured the students would understand the English language. When he discovered that while they might understand the written word, they could not understand a lecture. He then, as he recounted it, switched to his second language, German, only to find that the difficulties were no less but now of his own making.

In 1926 Professor Caldwell was appointed to the Ohio Committee on Motor Vehicle Lighting Legislation and to the Illuminating Engineers Society of America. He was a member of the Section and Papers Committee of the American Institute of Electrical Engineers. In the same Institute, he was a member of the Subcommittee on Mechanics, Structural Engineering and Testing Materials and also a member of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations. He was a Fellow in the Institute of Electrical and Electronic Engineers.

Professor Caldwell yielded the chairmanship of the department to newly-arrived Professor Erwin Ernest Dreese on January 1, 1930. He retired before the end of 1930. His only textbook entitled Modern Lighting was completed in the same year. On July 21, 1953, he died at age 84.

Figure 8
Professor Francis C. Caldwell

Dreese, Erwin Ernest

B. S., E. E., 1920, M. Sc., 1922, E. E., 1930 University of Michigan

1920-25 Instructor, University of Michigan

1925-30 Chief Engineer, Lincoln Electric Company

January 1, 1930-1965, Chairman and Professor of Electrical Engineering Department

1937--Chairman and Treasurer of Board of Trustees, The James F. Lincoln Arc Welding Foundation

Past Member and Vice-Chairman of the Council Executive Board, Argonne Lab. A. E. C.

Fellow, Institute of Electrical and Electronic Engineers

Professor Dreese came to Ohio State to take over the duties as chairman of the department on January 1, 1930, after Professor Caldwell had asked to be relieved of the responsibility. He brought a wide diversity of talent needed to guide the department through the depression years of the 1930's, the World War II years of 1939-45 and the great growth of Government-Sponsored research and resulting influx of graduate students beginning in 1946. He became Professor Emeritus in 1965 and turned over the department administration to Dr. Marlin O. Thurston at that time.

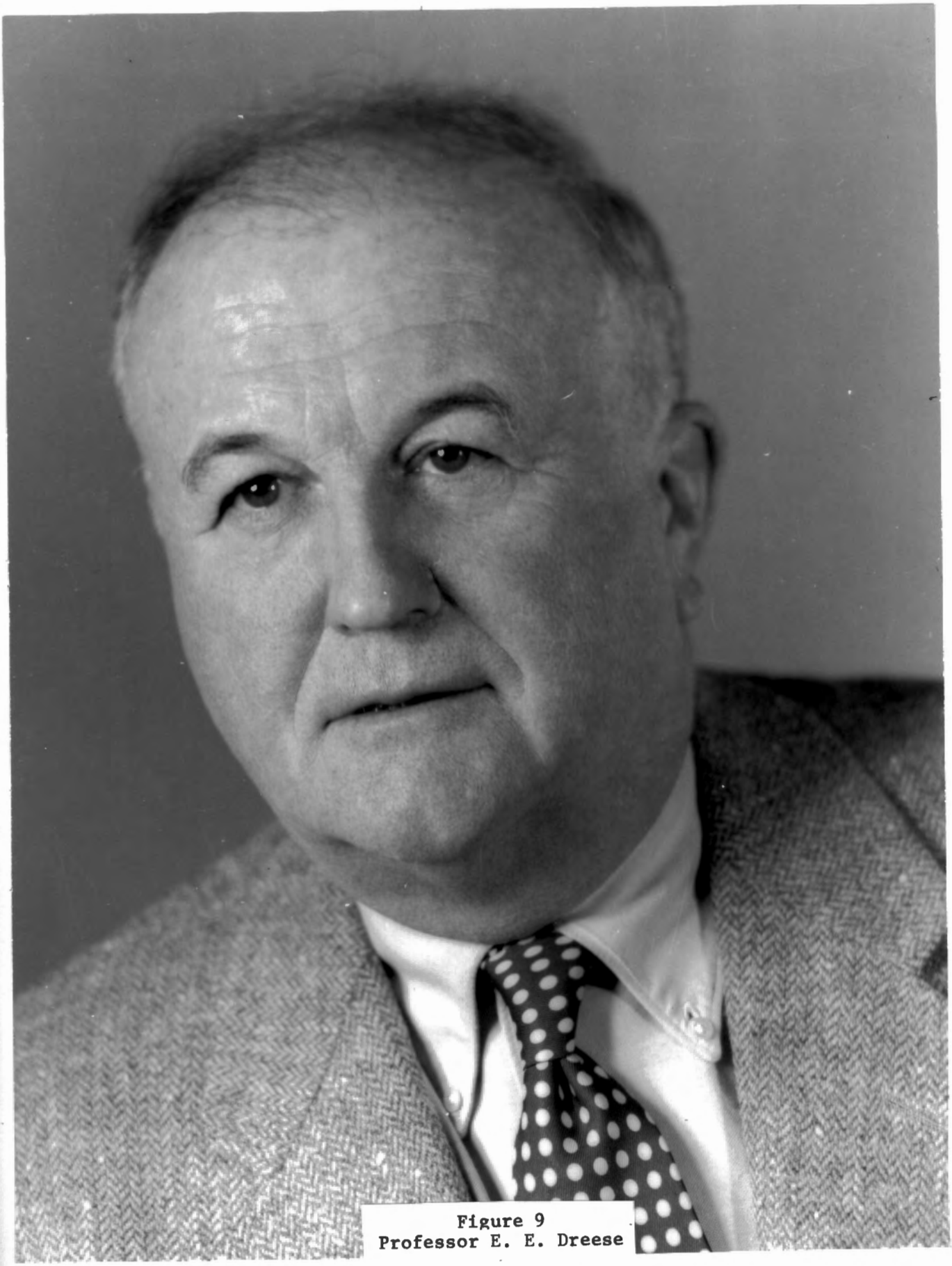


Figure 9
Professor E. E. Dreese

Thurston, Marlin Oakes

B. A. 1940, M. S. 1946 University of Colorado

Ph. D. 1955, Ohio State University

1940-42 Graduate Assistant University of Colorado

1942-46 Radar Officer U. S. Army Signal Corps and Air Corps

1946-52 Acting Head of Department of Electrical Engineering U. S. A. F. Institute of Technology at Wright-Patterson Air Force Base, Dayton, Ohio

1952-55 Researcher in Electron Tube Laboratory with the Ohio State University Research Foundation

1955-65 Associate Professor and Professor of Electrical Engineering at Ohio State University

1965--Professor and Chairman ibid.

Organizations:

Fellow, Institute of Electrical and Electronic Engineers

American Association for the Advancement of Science

American Physical Society

American Society for Engineering Education

Figure 10
Professor Marlin O. Thurston

THE FACULTY

In this chapter it is intended to list all department teaching personnel who have taught full or part-time with academic rank of Assistant Professor of higher. Many other men with the rank of Instructor have made outstanding contributions in teaching and others have distinguished themselves in their devotion to research. However, this list will be restricted to names of those men who have been regarded as members of the permanent faculty.

The academic rank and degree shown after every member's name are the highest held while connected with Ohio State University. The years shown indicate the earliest and the latest years of service. Interim periods in which a faculty member has been on leave or loan have not been indicated here.

1893			
Caldwell, Francis Cary	Prof.	M. Sc.	1893-53
1901			
Fish, Fred Alan	Asst. Prof.		1901-05
1905			
Anderegg, Gustavus A.	Assoc. Prof.		1905-08
Coggeshall, Allan	Asst. Prof.		1905-07
1907			
Hunt, John Herman	Prof.		1907-12

1908			
Upson, Walter Lyman	Asst. Prof.		1908-10
1910			
McOmber, Loren W.	Asst. Prof.		1910-11
1912			
Shepardson, John E.	Asst. Prof.		1912-33
Flowers, Alan Estis	Prof.		1912-19
Brown, Roy Atkinson	Asst. Prof.		1912-25
1916			
Kellogg, Edward W.	Asst. Prof.		1916-17
1918			
Puckstein, Albert E.	Assoc. Prof.	M. Sc.	1918-31
Wright, Charles Allan	Prof.		1918-27
1924			
Kimberly, Emerson E.	Prof. Em.	M. Sc.	1924-69
1925			
Tang, Kwan Yao	Prof.	Ph. D.	1925-60
Everitt, William L.	Prof.	Ph. D.	1925-44
1930			
Byrne, John Francis	Asst. Prof.	M. Sc.	1930-37
Campbell, Ivor St. Clair	Assoc. Prof.	M. Sc.	1930-31
Dreese, Erwin Ernest	Prof. Em.	M. Sc.	1930--
1932			
Bibber, Harold Whitney	Assoc. Prof.	M. Sc.	1932-42
1934			
Hazen, Harold L.	Exch.	Ph. D.	1934-35

1936			
Williams, Jerome E.	Asst. Prof.	M. Sc.	1936-41
1937			
Boone, E. Milton	Prof.	M. Sc.	1937--
Higgy, Robert C.	Assoc. Prof. Em.		1937--
1939			
Davis, Wells L.	Asst. Prof.	M. Sc.	1939-51
Evans, Sidley O.		M. Sc.	1939-44
1940			
Prebus, Albert F.	Assoc. Prof.	Ph. D.	1940-47
1941			
Jordan, Edward C.	Asst. Prof.	Ph. D.	1941-45
1942			
Ayres, Edmund D.	Prof.	S. M.	1942--
Weimer, Frank C.	Prof.	Ph. D.	1942--
1943			
Wang, Theodore J.	Asst. Prof.	Ph. D.	1943-48
1944			
Barbulesco, C. D.	Prof.	Ph. D.	1944-46
Zlotowski, Ignace	Asst. Prof.	Ph. D.	1944-46
1945			
Nelson, Paul H.	Asst. Prof.	M. Sc.	1945-46
Warren, C. Earl	Prof.	M. Sc.	1945--
1946			
Bacon, John	Prof.	Ph. D.	1946--

1946

Kraus, John D.	Prof.	Ph. D.	1946--
Mueller, George E.	Prof.	Ph. D.	1946-57
Weed, Herman R.	Prof.	M. Sc.	1946--
Davis, William C.	Prof.	M. Sc.	1946--

1947

Kirschbaum, Herbert S.	Assoc. Prof.	Ph. D.	1947-57
Smith, Neal A.	Prof.	M. Sc.	1947--

1948

Bertram, Sidney		Ph. D.	1948-49
Eaton, (Carter) Joy J.	Asst. Prof.	Ph. D.	1948-58
Rumsey, Victor H.	Assoc. Prof.		1948-54

1949

Masters, R. Wayne	Asst. Prof.	Ph. D.	1949-58

1951

Tice, Thomas E.	Prof.	Ph. D.	1951-62
Cowan, John D.	Prof.	M. Sc.	1951--

1952

Cosgriff, Robert L.	Prof.	Ph. D.	1952-67

1954

Kennaugh, Edward M.	Prof.	Ph. D.	1954--
Tai, Chen To	Prof.	D. Sc.	1954-64
Walter, Carlton H.	Prof.	Ph. D.	1954--

1955

Davis, Dean T.	Assoc. Prof.	Ph. D.	1955--
Kouyoumjian, Robert G.	Prof.	Ph. D.	1955--
Tischer, Frederick J.	Assoc. Prof.	Ph. D.	1955-62
Richmond, Jack H.	Prof.	Ph. D.	1955--

1956

Thurston, Marlin O.	Prof.	Ph. D.	1956--
Ward, Roy C.	Asst. Prof.	Ph. D.	1956-57
Ko, Hsien-Ching	Prof.	Ph. D.	1956--
Levis, Curt A.	Prof.	Ph. D.	1956--
Carter, Clarence J.	Asst. Prof.	Ph. D.	1956-57
Erdman, Arthur C.	Asst. Prof.	M. Sc.	1956--
Cornetet, Wendell H.	Prof.	Ph. D.	1956--
Campbell, Richard M.	Asst. Prof.	Ph. D.	1956--

1957

Gilfert, James C.	Assoc. Prof.	Ph. D.	1957-66
McFarland, Richard H.	Asst. Prof.	Ph. D.	1957-62

1958

Nash, Robert T.	Assoc. Prof.	Ph. D.	1957-66

1959

Battocletti, Frank E.	Assoc. Prof.	Ph. D.	1959--
Chang, Wm. Shen Chie	Assoc. Prof.	Ph. D.	1959-65
Lackey, Robert B.	Assoc. Prof.	Ph. D.	1959--
Peake, Wm. H.	Prof.	Ph. D.	1959--
Peters, Leon Jr.	Prof.	Ph. D.	1959--

1960

Mathis, Harold F.	Prof.	Ph. D.	1960--

1961

Hame, T. Gordon	Asst. Prof.		1957-61
Fenton, Robert E.	Assoc. Prof.	Ph. D.	1961--

1962

Hsu, Hsiung	Prof.	Ph. D.	1962--
Swartz, John M.	Asst. Prof.	Ph. D.	1962--
Josenhans, James	Asst. Prof.	Ph. D.	1962-63

1963

Todosiev, Ernest P.	Asst. Prof.	Ph. D.	1963-64

1963

Long, Ronald K.	Assoc. Prof.	Ph. D.	1963--
Potts, Byron C.	Asst. Prof.	Ph. D.	1963-64

1964

Collins, Stuart A.	Assoc. Prof.	Ph. D.	1964--

1965

Koozekanani, S. H.	Assoc. Prof.	Ph. D.	1965--
Gottling, James G.	Assoc. Prof.	Sc. D.	1965--
Anderson, William W.	Assoc. Prof.	Ph. D.	1965--
Rudduck, Roger C.	Asst. Prof.	Ph. D.	1965--
Middleton, Arthur E.	Prof.	Ph. D.	1965--

1966

DeVore, Robert V.	Asst. Prof.	Ph. D.	1966--
Hemami, Hooshang	Asst. Prof.	Ph. D.	1966--
Hodge, Daniel B.	Asst. Prof.	Ph. D.	1966--
Yovits, Marshall C.	Prof.	Ph. D.	1966--
Ksienski, Akaron A.	Prof.	Ph. D.	1966--

1967

Ehman, Jerry R.	Asst. Prof.		1967--
Breeding, Kenneth J.	Asst. Prof.	Ph. D.	1967--
Mayhan, Robert J.	Asst. Prof.	Ph. D.	1967--
McMaster, Robert C.	Prof.	Ph. D.	1967--
Meadors, John G.	Asst. Prof.	Ph. D.	1967--
Olson, Karl William	Asst. Prof.	Ph. D.	1967--

1968

White, Lee J.	Asst. Prof.	Ph. D.	1968--
Sebo, Stephen A.	Assoc. Prof.	Ph. D.	1968--
McGhee, Robert B.	Prof.	Ph. D.	1968--

MAJOR PUBLICATIONS

The publications listed here are books of which the named faculty member is author or co-author and which have been published. Articles published in technical magazines, talks made before technical societies and reports on research are considered too numerous to list in this history.

1914

Francis Cary Caldwell
Electrical Engineering Problems — McGraw-Hill

1925

Charles Allen Wright (with A. F. Puckstein)
Telephone Communications — McGraw-Hill

1930

Francis Cary Caldwell
Modern Lighting — The McMillan Co.

1932

William Littell Everitt
Communication Engineering — McGraw-Hill

1936

Albert F. Puckstein (with Tom C. Lloyd)
Alternating Current Machines — J. Wiley & Sons

1940

Emerson Edward Kimberly
Electrical Engineering — International

1940

Kwan Yau Tang
Alternating Current Circuits — International

1943

Theodore J. Wang
Mathematics of Radio Communication — D. Van Nostrand

1947

Edmund Dale Ayres
Engineering Economy

1950

John D. Kraus
Antennas — McGraw-Hill

1953

E. Milton Boone
Circuit Theory of Electron Devices — J. Wiley & Sons

John D. Kraus
Electromagnetics — McGraw-Hill

Herman Roscoe Weed (with Wells L. Davis)
Industrial Electronic Engineering — Prentice-Hall

1959

Herman Roscoe Weed (with Wells L. Davis)
Fundamentals of Electron Devices — Prentice-Hall

1961

John D. Cowan (with Herbert S. Kirschbaum)
Introduction to Circuit Analysis — C. E. Merrill

1965

Carlton H. Walter
Travelling Wave Antennas — McGraw-Hill

MISCELLANEOUS EVENTS, LARGE AND SMALL

1889 Legislature appropriated $10,000.00 for building and equipping Electrical Hall. First laboratory equipment dontated. First telephone line in the state built between University Hall and Eleventh Avenue at High Street. Electrical Engineering curriculum introduced Professor Benjamin F. Thomas of Department of Physics. Electrical Hall built.

1896 First Fellowship in Electrical Engineering created ($300.00).

1898 Electrical Engineering first recognized in catalog.

1899 National Meeting of SPEE (now ASEE) held at O. S. U.

1900 Master's Degree authorized.

1901 Four-Quarter Curriculum first proposed.

1904 Charles F. Kettering graduated.

1906 Inspection trips first required for graduation.

1907 Robinson Laboratory built. James F. Lincoln left before graduating because of typhoid epidemic. First option in illumination offered.

1908 Two-Term (Semester) curriculum proposed.

1909 First course in wireless telegraphy offered. Semester schedules first laid out.

1910 First wireless telegraphy actually taught. Radio station started as receiving station. Professor Caldwell on leave-of-absence; Professor Hunt Acting Chairman.

1911 M. E. in E. E. designation discontinued as offering in favor of B. E. E. degree.

1913 Professor F. C. Caldwell on first Advisory Council for Engineering Experiment Station. First course in Radio Communication (Special) offered. Radio station with transmitting equipment important communication link with outside world during 1913 flood.

1917 Semester plan first put in operation.

1918 Four-Quarter plan reset to start in 1921, but not implemented.

1919 The University's educational radio station began broadcasting experimentally with the call letters 8 X I. The station was designed, built and operated by Robert C. Higgy. Call changed to WEAO in 1922 and WOSU in 1931.

1922 Four-Quarter curriculum started in summer. Point-Hour system of grading started by University. Radio broadcasting started with evening entertainment and educational programs from radio station as WEAO. Most of the equipment was bought with funds donated by Franklin County Alumni Association.

1923 Regular radio program started and fulltime operator for station appointed. Electrical Engineering Department expanded into part of Communication Laboratory.

1924 Charles F. Kettering '04 as Chairman of Board of Trustees made first report to Governor.

1925 Radio station WEAO separated from Electrical Engineering

Department but Professor Charles A. Wright was retained as its first Director. Professor F. C. Caldwell started one-year leave of absence to lecture in Europe. Senate Bill No. 26 to provide new broadcasting station under consideration.

1926 James F. Lincoln received E. E. degree.

1927 Honors Group to benefit superior students used first time.

1928 Ohio State Radio Club formed.

1929 Lamme Scholarship first made available.

1930 On January 1, Professor F. C. Caldwell retired as Department Chairman. Professor Erwin E. Dreese assumed Chairmanship.

1931 Lamme Medal awarded first time in June. Award was made to Charles Edward Skinner '90.

1932 First course in Applied Electronics offered.

1934 Assistant Professor John F. Byrne went to Massachusetts Institute of Technology on a one-year interchange with Dr. Harold L. Hazen.

1935 Honors Group re-activated after a few years of dormancy caused by lack of sufficient teaching personnel.

1937 Transportation as a course offering was withdrawn. Broadcast Engineering Conference started and held first time in February, 1938.

1941 Electron Microscope completed by Dr. Albert F. Prebus. Power supply for O. S. U. cyclotron designed by Dr. Edward C. Jordan. Charles F. Kettering '04 was re-appointed to the Board of

Trustees (Previously 1917-25).

1943 James F. Lincoln '07 appointed to Board of Trustees. Siefried Frederick Singer received B. E. E. degree. See Distinguished Alumni.

1945 Five-year curriculum adopted to become effective in 1946.

1946 Five-year curriculum became effective in autumn quarter. Electron tube laboratory started.

1948 Electron tube laboratory started operation, E. M. Boone, Director.

1949 Construction started on Caldwell Laboratory.

1950 Occupation of Caldwell Laboratory started. First class graduated under five-year curriculum.

1953 First year in which Transistor Theory was taught.

1956 Antenna Laboratory (now part of ElectroScience Laboratory) opened on Kinnear Road. Dish antenna completed for Radio Observatory off Kenny Road on west campus. Work started on parabolic reflector360 feet long by 70 feet high to be used as new antenna for Radio Observatory at Perkins Observatory off Route 23, south of Delaware, Ohio. At this observatory radio-frequency radiation was first discovered from Comet (Arend-Roland) in April.

1958 Courses in Energy Conversion introduced.

1961 Work started on four steerable 30-foot diameter parabolic reflector antennas at ElectroScience Laboratory under a

$435,000.00 research contract with the United States Air Force. They are used for satellite tracking as well as inter-continental and interplanetary communication.

1963 Instruction by television between Ohio State University and Wright-Patterson Air Force Institute of Technology was initiated in 1962 when the University made an appropriation of $10,000.00 to the Graduate School for that purpose. In 1963, the Electrical Engineering Department started using the wire and microwave link for instruction in graduate courses.

1965 Professor Erwin E. Dreese retired. Dr. Marlin O. Thurston assumed the Chairmanship. Bio-Medical Engineering introduced and promoted by Professor H. R. Weed.

REFERENCE SOURCES

History of Ohio State University II 1910-1925 by Osman C. Hooper.

History of Ohio State University Vol. 1 (1870-1910).

Reports of the President to the Board of Trustees.

Alumni Records (Departmental and Alumni House).

University Catalogues.

University Commencement Programs.

University Directories.

History of the Electrical Engineering Department by Francis Cary Caldwell.

Minutes of Meetings of Engineering College Faculty.

Memories of Faculty still living.

Appendix I

For Degree Mechanical in Electrical Engineering From Catalog 1889

Freshman Year

Fall Term	Hr.	Winter Term	Hr.	Spring Term	Hr.
French	5	French	5	French	5
Chemistry	4	Chemistry	2	Lettering	2
Mathematics	3	Mathematics	3	Mathematics	3
English	2	English	2	English	2
Mechan. Lab.	2	Mechan. Lab.	2	Mechan. Lab.	2
		Drawing	1	Drawing	1

Sophomore Year

Fall Term	Hr.	Winter Term	Hr.	Spring Term	Hr.
Mathematics	5	Mathematics	5	Mathematics	5
Physics	5	Physics	5	Physics	5
Project. Draw.	3	Drawing	3	Drawing	3
Phys. Lab	2	Phys. Lab.	3	Mechan. Lab	3
Mechan. Lab	2	Rhetoricals	-	Rhetoricals	-
Rhetoricals	-				

Junior Year

Fall Term	Hr.	Winter Term	Hr.	Spring Term	Hr.
Mechanics	5	Mechanics	5	Str. of Mater.	5
Physics	3	Mechanism	5	Physics	3
Least Squares	1	Physics	5	Mechanism	2
Mechanism	2	Rhetoricals	-	Tech. Draw.	5
Des. & Draw.	5			Rhetoricals	-
Rhetoricals	-				

Senior Year

Fall Term	Hr.	Winter Term	Hr.	Spring Term	Hr.
Elect. Engg.	5	Elect. Engg.	5	Elect. Engg.	3
Thermodyn.	5	Prime Movers	5	Millwork	5
Tech. Draw.	3	Tech. Draw.	3	Tech. Draw.	5
Elect. Lab.	3	Elect. Lab.	3	Elect. Lab.	3

In June of 1891 the Senior Year courses were slightly rearranged as follows:

Fall Term	Hr.	Winter Term	Hr.	Spring Term	Hr.
Elect. Engg.	5	Elect. Engg.	5	Elect. Engg.	3
E.E. Lab.	5	E.E. Lab.	5	E.E. Lab.	5
Thermodyn.	5	Thermodyn.	5	Thermodyn.	5
Tech. Draw.	3	Tech. Draw.	3	Tech. Draw.	5

It is significant to note the weight still given to the mechanical engineering subject of Thermodynamics and also to Technical Drawing which was removed from the curriculum many years before the Centennial year of 1970. But, after all, the degree offered was M.E. in E.E.

Appendix II
1893-1894

Sophomore Year

1st. Term	Hr.
Mathematics	5
Physics	3
Mechan. Lab.	5
English	1
Physics	2
Mil. Sc.	-

2nd. Term	Hr.
Mathematics	5
Physics	3
Physics	2
Physics	5
English	1
Drawing	3
Mil. Sc.	-

3rd. Term	Hr.
Mathematics	5
Physics	3
Physics	2
Physics	5
English	1
Drawing	3
Mil.Sc.	-

Junior Year

1st. Term	Hr.
Mechanics	5
Mechanism	2
Physics	3
Physics	3
Drawing	3
Mathematics	2
English	1

2nd. Term	Hr.
Mechanics	5
Mechanism	5
Physics	5
Mechan. Lab.	3
English	1

3rd. Term	Hr.
Strength of Materials	5
Physics	5
Mechan. Lab.	3
Drawing	5
English	1

Senior Year

1st. Term	Hr.
Thermodyn.	5
Elec. Engg.	2
Elec. Engg.	3
Elec. Engg.	5
Tech. Draw.	3

2nd. Term	Hr.
Prime Movers	5
Elec. Engg.	5
Elec. Lab.	5
Tech. Draw.	3

3rd. Term	Hr.
Machinery M.E.	5
Elec. Engg.	3
Elec. Lab.	5
Tech.Draw.	5

Thesis

Appendix III
1968 - 1969

500 Electrical Engineering
501 Circuit Theory I
502 Circuit Theory II
503 Circuit Theory III
504 Circuit Theory IV
507 Electrical Laboratory I
508 Electrical Laboratory II
510 Field Theory I
511 Field Theory II
512 Transmission and Radiation
517 Electrical Laboratory III
520 Electron Devices and Controls
540 Electrical Engineering
580 Professional Aspects of Electrical Engineering
581 Experience in Practice

620 Electron Device Circuit Theory I
621 Electron Device Circuit Theory II
622 Electron Device Circuit Theory III
627 Electrical Laboratory IV
628 Electrical Laboratory VI
630 Introduction to Electron Devices
631 Electron Device Physical Theory I
632 Electron Device Physical Theory II
640 Electrical Energy Conversion I
641 Electrical Energy Conversion II
642 Electrical Energy Conversion III
647 Electrical Laboratory V
650 Introduction to Feedback Analysis
657 Electrical Laboratory VII
660 Logic Circuit Theory
684 Economics and Organization of the Electrical Industry
693 Individual Studies in Electrical Engineering
694 Group Studies in Electrical Engineering

700 Advanced Circuits
701 Communication Theory
702 Communications Systems
703 Space Communications
707 Communications Laboratory I
708 Communications Laboratory II
710 Microwave Circuits
711 Radiation from Antennas
712 Microwave Optics
713 Elements of Radio Wave Propagation
714 Microwave Electronics
715 Radio Astronomy Instrumentation
717 Antenna Laboratory
718 Microwave Circuits Laboratory
720 Circuit Theory of Solid State Devices

Appendix III
1968 - 1969

721 Advanced Electronic Circuits
727 Solid State Device Laboratory
728 Advanced Electronic Circuits Laboratory
732 Quantum Electron Devices
733 Nonlinear Interactions of Fields
740 Introduction to Electric Power Systems
741 Electric Power Networks
742 Problems in Electric Power Systems
747 High Voltage Laboratory
748 Power System Laboratory
751 Open Cycle Control and Instrumentation
752 Feedback Control Systems
753 Magnetic Amplifiers
754 Advanced Control Systems
757 Control Systems Laboratory I
758 Control Systems Laboratory II
760 Theory and Design of Digital Computers
761 Advanced Logic
762 Information Theory
767 Digital Computer Laboratory
770 Biological Control Systems
771 Bio-Electrical Instrumentation
794 Advanced Studies in Electrical Engineering

800 Transients in Linear Systems
801 State Variable Methods in Linear Systems
802 Network Synthesis I
803 Network Synthesis II
804 Communication Theory I
805 Communication Theory II
806 Communication Theory III
808 Theory and Analysis of Magnetic Amplifiers
809 Analysis of Magnetic Amplifiers Memory Devices and Components
810 Fundamentals of Electromagnetic Theory
811 Waveguides and Resonators
812 Theory of Microwave Components
813 Radiation and Radiating Systems
814 Advanced Antenna Theory I
815 Advanced Antenna Theory II
816 Propagation of Electromagnetic Waves
817 Advanced Electromagnetic Theory I
818 Advanced Electromagnetic Theory II
819 Advanced Electromagnetic Theory III
820 Methods of Analysis of Interaction Between Electrons and Fields
821 Theory of Electron Guns and Electron Beams
822 Velocity Variation Electron Tubes
823 Electron Interaction with Traveling Waves
829 Plasma Dynamics
830 Solid State Electron Devices I

Appendix III
1968 - 1969

831 Solid State Electron Devices II
832 Solid State Electron Devices III
833 Theory of Semiconductor Junction Devices
834 Quantum Electron Devices
835 Quantum Electron Devices
836 Quantum Electron Devices
837 Dielectric and Magnetic Electronics
838 Semi-Insulator Electronics
840 Electromechanical Systems
850 Theory and Design of Feedback Control Systems
851 Synthesis of Linear Feedback Control Systems
853 Analysis of Non-Linear Systems
854 Modern Control Theory I
855 Modern Control Theory II
860 Information Science I
863 Advanced Coding Theory I
864 Advanced Coding Theory II
865 Advanced Sequential Logic

Radio Astronomy Theory I (see under Astronomy 862)
Radio Astronomy Theory II (see under Astronomy 863)

880 Advanced Studies in Electrical Engineering
881 Seminar in Electrical Engineering
895 Interdepartmental Seminar in Radio Astronomy
899 Interdepartmental Seminar

910 Advanced Antenna Theory III
999 Research in Electrical Engineering

Appendix IV

The Five-Year Curriculum
1946

Second Year

Fourth Quarter	Hr.
Math (Calculus)	5
Physics (Mech.)	5
Econ. (Prin.)	3
Elec. Eng.	2
Mil. Sc.	2

Fifth Quarter	Hr.
Math (Calculus)	5
Physics (Heat, Sound & Light)	5
Econ. (Prin.)	3
Ind. Eng. (Forg., Heat Treat, Weld.)	3
Mil. Sc.	2

Sixth Quarter	Hr.
Math (Calculus)	5
Physics (Elec. & Magnetism)	4
History (U.S. 1898 to 1920)	3
Elec. Eng.	2
Ind. Eng. (Mach. Shop)	3

Third Year

Seventh Quarter	Hr.
Mechanics (Statics)	5
Mech. Eng. (Thermo Dynamics)	5
History (U.S. since 1920)	3
Physics (Elec. & Magnetism)	5

Eighth Quarter	Hr.
Mechanics (Strength of Materials)	5
Physics (Elec. & Magnetism)	5
Elec. Eng.	5
Elec. Eng. Lab.	2

Ninth Quarter	Hr.
Elec. Eng. (Med. & H.F.)	4
Mechanics (Dynam.)	3
Mech. Eng. (Heat Power)	3
Mechanics (Mech. of Fluids)	3
Sociology (Intro.)	3
Speech (Prin. of Public Speaking)	3

Summer Quarter	Hr.
Elec. Eng. (Experience in Prectice)	5

Appendix IV (cont.)

Fourth Year

Tenth Quarter	Hr.
Elec. Eng.	4
Mech. Eng. Lab.	2
Elec. Eng.	4
Elec. Eng.	4
Sociology (Intro.)	3

Eleventh Quarter	Hr.
Elec. Eng.	4
Elec. Eng.	3
Mech. Eng. Lab.	3
Elec. Eng.	4
Elec. Eng.	2
International Studies (Background of Comtemporary Civilization)	3

Twelfth Quarter	Hr.
Elec. Eng.	3
Physics	4
Elec. Eng.	3
Elec. Eng.	4
Elec. Eng.	2
International Studies (Background of Contemporary Civilization)	3

Fifth Year

Thirteenth Quarter	Hr.
Broaden, Elective	5
Ethics & Assembly	0
Elec. Eng.	2
Elec. Eng. (Opt.)	4
Elective	5

Fourteenth Quarter	Hr.
Broaden, Elective	5
Ethics & Assembly	0
Mech. Eng.	4
Elec. Eng. (Opt.)	4
Elective	5

Fifteenth Quarter	Hr.
Broaden, Elective	5
Ethics & Assembly	1
Elec. Eng.	4
Elec. Eng. (Opt.)	4
Elective	5

Appendix V

The following courses are recommended electives for Electrical Engineers preparing for Bio-Medical Engineering:

E.E. 770 Biological Control Systems
Two class hours and three lab. hours per week.

771 Bio-Medical Instrumentation
Two class hours and three lab. hours per week.

772 Advanced Bio-Medical Instrumentation
Two class hours and three lab. hours per week.

870 Biological System Modeling I
Two class hours and three lab. hours per week.

871 Biological System Modeling II
Two class hours and three lab. hours per week.

These blocks of course material in engineering and physical sciences have been planned to provide either three or six months of concentrated work in this area for the medical student:

First Quarter

Math. XXX Basic Engineering Math., five hours per week.
Engg. XXX Basic Engineering and Control Theory, five hours per week.
E.E. XXX Elec. and Electronic Circuits, five hours per week.
Engg. XYY Engineering Lab., two classes per week.

Second Quarter

Engg. XXY Basic Engineering and Control Theory II, five hours per week.
Engg. YYY Applied Problems, three hours per week.

See: Addendum to this history in Electroscience Laboratory (Formerly: Antenna Laboratory) Vertical Information File

APPENDIX VI

THE HISTORY OF THE ELECTROSCIENCE LABORATORY

(Formerly Antenna Laboratory)

The Antenna Laboratory had its inception in 1941 when Prof. W.L. Everitt (now Dean Emeritus of the College of Engineering at the University of Illinois) invented a new model measurement technique for aircraft antennas. All model techniques, which are now general practice but were then in their infancy, utilize small metallic models of the aircraft, often at 20th or 40th scale, and the measurements are performed at a correspondingly higher frequency, i.e., 20 or 40 times the antenna design frequency. The results are much more convenient to obtain than full-scale measurements and also are usually more accurate.

As used prior to 1941, the model might contain either a small battery-powered transmitter or a receiver. Available technology limited the transmitter method to the lower frequencies, while the receiver method required a cable for bringing the signal back to be recorded, and this cable introduced certain inaccuracies. Prof. Everitt's novel idea was to insert a modulator at the model antenna terminals, to irradiate the model with a microwave source, and to receive the modulated component of the reradiated signal.

Two of Prof. Everitt's graduate students, George Sinclair and Sidney Bertram, began to implement the new technique and also to improve the equipment and procedures available for the previously used model techniques which have continued to be very useful. When Everitt left Columbus for a war-time assignment in Washington, Dr. E.C. Jordan (then an instructor in Electrical Engineering at The Ohio State University, now Chairman of the Electrical Engineering Department at the University

of Illinois) greatly assisted with his guidance and advice, but because of Jordan's heavy teaching load the primary responsibility for the fledgling project was assumed by Sinclair. The group was soon joined by two more graduate students, Eric Vaughan and Paul H. Nelson.

Sinclair, who had lost a brother early in the War, found in this work an opportunity to express his personal commitment to the Allied cause. He was therefore willing to have the group expand, even though the increased administrative requirements would slow his own academic progress. Dr. Jordan's ever available advice was a source of additional technical strength. The time was propitious because of war-time requirements for aircraft antennas and an increasing reliance on model measurements to predict the antenna performance before a full-scale prototype was built. Utilization of model techniques to evaluate the responses of radars to aircraft and to artillery shells further increased the growth potential of the group. The responsibility of deciding whether or not to allow and encourage growth belonged to Prof. Dreese as Department Chairman. Although Sinclair was only a graduate student, Prof. Dreese decided to support his efforts, and by 1946 the group had grown to approximately 50 employees and become known as the Antenna Laboratory. (Dr. Sinclair is now Professor of Electrical Engineering at the University of Toronto and President of Sinclair Radio Laboratories Limited; Dr. Bertram is Senior Staff Scientist with the Bunker-Ramo Corporation; Mr. Vaughan is Vice President of Research and Development and Director of the Superior Electric Co.; Mr. Nelson was Professor of Engineering at San Fernando Valley State College until his death in 1967.)

The research was first performed in the Communications Laboratory on 19th Avenue. As the scale-model measurement program expanded, this space became insufficient and interference from near-by structures became intolerable. The experimental program was moved in 1946 to two Quonset huts located at the edge of the ROTC drill field on Tuttle Park Road. As programs expanded, a series of small trailers was added for additional work space. The working conditions were not ideal: in the summer the trailers became so hot that paraffin, used as dielectric in the antennas mounted on the trailers, would melt, requiring measurements to be completed well before noon. In winter it was essential to light the oil stove at least half an hour or forty-five minutes before starting work to allow the equipment to come up to reasonable temperature (to say nothing of the operators!). Nevertheless, many valuable measurements were obtained in those trailers. Many of the antenna ranges now commonly in use by aircraft and antenna companies are descendants of the hand-built equipment first used in the Quonset huts.

When Dr. Sinclair left Ohio State after obtaining his Ph.D. degree in 1946, Mr. Robert P. Jacques took over the guidance of the Laboratory. After approximately a year, Mr. Jacques and some others from the Laboratory staff formed their own company for the measurement of antenna patterns. This first spin-off, Antenna Research Laboratory, Inc., later was acquired by a larger company--as also happened with several later spin-offs.

Prof. Victor H. Rumsey became Supervisor of the Laboratory in 1948. A brilliant theoretician and inspiring teacher, he attracted a large number of excellent graduate students. He became the academic adviser of many of them and a strong influence on all. Of the group who joined

the Laboratory about this time, some eventually became distinguished in their own right and joined the faculty of The Ohio State University (Professors Bacon, Kennaugh, Kouyoumjian, Levis, Peake, Peters, Richmond, Walter). Others have had distinguished careers elsewhere: Dr. John R. Mentzer, Head of Engineering Sciences at Pennsylvania State University; Dr. R.F. Harrington, Professor of Electrical Engineering at Syracuse University and author of several books on electromagnetic theory; Dr. Thomas H. Crowley, Executive Director of the SAFEGUARD Design Division at Bell Telephone Laboratories; Dr. Marshall H. Cohen, Professor of Radio Astronomy at the California Institute of Technology; Dr. Donald Rhodes, Professor of Electrical Engineering at North Carolina State University and recipient of the 1963 Bolljahn Award; Dr. Thomas E. Tice, Chairman of the Department of Electrical Engineering at the Arizona State University; Mr. J. Ned Hines, Technical Staff Member of the Antenna Research Department, Bell Telephone Laboratories; the list is obviously incomplete.

Even during the early days of the Laboratory under Sinclair, the model technique had been extended to radar measurements. The theory and measurement of radar scattering now received new emphasis and, primarily due to work by Kennaugh, became a major part of the activities of the Laboratory. Prof. Rumsey himself made and inspired important contributions in electromagnetic theory, traveling-wave antennas, and frequency-independent antennas. For the latter idea, conceived only shortly before he left for the University of Illinois and brought to fruition there, he received the 1962 Morris Liebman Award of the Institute of Radio Engineers.

As the Laboratory grew, Prof. Rumsey found it essential to delegate some of the research management responsibilities. Robert A. Fouty had joined the Laboratory in its early days as a member of the technical staff but soon became active in its administrative affairs. He was appointed

Research Manager in 1948. Now Associate Director of the Laboratory, Mr. Fouty has been involved in its research management ever since and has, in large part, been responsible for the growth of the Laboratory and the style of its work.

When the Caldwell Laboratory Building was finished in 1950, the Antenna Laboratory occupied the fourth floor and part of the third floor, but most of the experimental activities still continued at the Quonset huts. There were some drawbacks to the drill-field location: when a platoon would come too close to the experimental facilities, all the instrument needles and recorder pens would wiggle. The resulting uncertainties were known popularly among the Laboratory staff as the "soldier effect." The construction of the St. John Arena immediately behind the experimental site finally made experiments at this location totally impossible, and plans for a facility at 1320 Kinnear Road were made. The first structure there was completed in 1955.

Prof. Rumsey left Ohio State in 1954 and Dr. Thomas E. Tice became Supervisor. During the seven years of his administration the style of the Laboratory changed considerably. Under Prof. Rumsey, the structure had been that of one professor and a group of graduate students, and the line of endeavor had adhered closely to Prof. Rumsey's own interests of electromagnetic theory and antennas. Under Dr. Tice, the activities of the Laboratory grew in breadth. More faculty and increasingly more graduate students became involved, and the programs were more diversified technically. New areas into which the Laboratory ventured were highway automation, quantum detectors, satellite communications, and plasmas.

Radome research received increased emphasis. A series of annual (later biennial) Radome Symposia at Ohio State brought together almost all research in this field, and a handbook Techniques for Airborne Radome Design was prepared under Tice's editorship. Considerable progress was also made in understanding the scattering of electromagnetic energy from rough surfaces, and much of this was collected in Terrain Scattering Properties for Sensor System Design by R.L. Cosgriff, W.H. Peake, and R.C. Taylor, a handbook which still enjoys considerable circulation a decade after its publication.

The expansion of the scope of the Laboratory is indicated by a change in titles: Dr. Tice became Director while the title "Supervisor" was reserved for those directly in supervision of research projects. Of great importance to the growth of the stature of the Laboratory during these years were the contributions in electromagnetic and antenna theory by Prof. C.T. Tai.

When family health problems forced Dr. Tice to leave the Columbus area in 1961, Dr. Curt A. Levis became the Director. Diversification of the Laboratory continued, faculty participation increased. The research staff of the Laboratory, formerly relatively distinct from the teaching faculty of the Department, now became closely intermingled.

By 1964 the projects in the information science areas had grown to such an extent that it was felt they would support a separate Laboratory. At this time the Communication and Control Systems Laboratory was split off from the Antenna Laboratory and placed under the direction of Dr. Robert L. Cosgriff (now Chairman of Electrical Engineering at the University of Kentucky). It has continued as an independent Laboratory to the present

time. Even with this reduction, the number of persons involved in the Laboratory grew to the point where new space was vitally necessary. An addition to the field station at 1320 Kinnear Road, more than doubling its floor space, was completed in 1964. Another building, largely underground and equipped with elaborate electrical facilities and climate control, was built for satellite communications research in connection with the four 30-foot parabolic antennas located in the field immediately behind 1320 Kinnear Road. This building was completed in 1966.

During the late 50's and the 60's, the interests of the Laboratory continued to broaden to encompass all types of systems utilizing radiant electromagnetic energy. Among the new areas of strength were communications through a plasma, under the leadership of Mr. Ross Caldecott. Remote sensing of terrain became Prof. Peake's area of expertise. Lasers and non-linear optics became an important area of research and instruction under the guidance of Mr. E.K. Damon, Prof. W.S.C. Chang (now Chairman of the Department of Electrical Engineering at Washington University), and Prof. H. Hsu, later joined by Profs. S.H. Koozekanani and John G. Meadors. A symposium on "Lasers and Applications" was held in 1962 and the papers presented were published as a book under Chang's editorship. Atmospheric optical propagation, with emphasis on laser system effects, became Prof. R.K. Long's specialty, while Prof. S.A. Collins studied the effects of turbulence on such systems and applications of holography, and Dr. W.G. Swarner explored the uses of coherent light in an ocean environment. The Satellite Communications research led to the design and implementation of a self-phased array of paraboloids for space communications, the demonstration of time-division multiple access

for satellite communication, and the detailed characterizations of several passive and active satellites. The name Antenna Laboratory was obviously inadequate to describe these activities, and it was changed to ElectroScience Laboratory in 1967. Antennas and electromagnetic theory continued to be a strong area of interest, however, with Prof. Walter and his graduate students playing an important role. Prof. Richmond and his graduate students pioneered in the use of computer techniques in the low-frequency domain, while Profs. Kouyoumjian, Peters, and Rudduck helped make the Theory of Geometrical Diffraction, developed by Keller at New York University about a decade before, a useful tool for the antenna and radar system designer and analyst. Radar scattering research under Prof. Kennaugh's guidance also continued to prosper.

With the interests of the Laboratory so greatly broadened, a re-organization by Technical Areas became advisable. Prof. Walter became Director for the Antennas area; Prof. A.A. Ksienski joined the Laboratory as Director of the Communications area; Mr. E.K. Damon who had long been active in the Laboratory in microwaves and lasers became responsible for Quantum Electronics and Plasmas; Prof. Kennaugh became Director for Electromagnetic Theory and Scattering, but resigned in favor of Prof. Peters when he found the responsibility too conflicting with his teaching and research interests.

Since 1965 the Laboratory has organized each summer for the Engineering College a "short course" in an area of its strength. The 1965 and 1966 topic was "Antenna and Scattering Theory - Recent Advances," 1967 and 1968 brought "Laser Propagation through the Atmosphere," and in

1969 "The Application of Optical Methods to Microwave Problems" was offered. In each case the purpose was to present the latest available material to a select group of workers in the particular area.

The present Laboratory staff of 120 includes 22 faculty (mostly on a part-time basis) and approximately 65 graduate students, supported by a small permanent staff of full-time engineers, technicians, and clerical help. As of 1 January 1969, 230 graduate degrees had been granted as a result of the programs of the Laboratory since its beginning.

Prof. Levis resigned the Directorship in August 1969 in order to have more time for teaching, writing, and research, and Prof. L.L. Bailin came to The Ohio State University as the new Director.